TEXAS DEPARTMENT OF WATER RESOURCES
1700 N. Congress Avenue
Austin, Texas

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The People of Texas

The Honorable Mark White
Governor of Texas

The Honorable Bill Hobby
Lieutenant Governor of Texas

The Honorable Gib Lewis
Speaker of the House

The Legislature of the State of Texas

Transmitted herewith is the amended Texas Water Plan which was adopted by the Texas Water Development Board on September 20, 1984 as the official water plan for the State. This amended water plan titled "Water for Texas: A Comprehensive Plan for the Future" has been in preparation since 1981 and is the result of a planning process which included public input through 13 public meetings, interviews with community and professional leaders, a public opinion poll, and nine public hearings.

Volume 1 of the amended plan is an executive summary which sets forth planned actions and policy recommendations. Volume 2 is a technical document which provides details of current water development and use, projected future water supply and wastewater treatment needs, and potentially developable water supplies to meet future water needs in each river and coastal basin of the State.

The planned actions and policy recommendations approved by the Board include actions to be taken by the Texas Department of Water Resources and recommendations to local, State, and federal entities and the Legislature to: (1) implement actions and programs intended to address the problem of inadequate longterm water supplies in certain areas of the State, (2) increase attention to flood protection and floodplain management at the State and local level, (3) maintain strong State involvement in protecting water quality, and (4) address problems associated with the increasing strain being placed upon local entities to cope with water supply, water quality protection, water conservation, flood protection, and other water-related needs.

The People of Texas
Governor of Texas
Lieutenant Governor
Speaker of the House
The Legislature

The accelerated population and economic growth which the State is currently experiencing is imposing severe pressures on the capabilities of local units of government to implement and finance new water supply and wastewater treatment facilities necessary to keep pace with such growth. Actions are needed now to insure that Texas State government is responsive to the needs of all of the citizens.

Respectfully submitted,

Texas Water Development Board

Louis A. Beecherl, Jr. Chairman

George W. McCleskey, Vice-Chairman

Glen E. Roney, Member

W. O. Bankston, Member

Lonnie A. "Bo" Pilgrim, Member

Louie Welch, Member

Charles E. Nemir, Executive Director

Water For Texas
A Comprehensive Plan for the Future

Volume 1

Section 16.051 of the Texas Water Code directs the Executive Director of the Department of Water Resources to prepare and maintain a comprehensive State water plan for the orderly development and management of the State's water resources in order that sufficient water will be available at a reasonable cost to further the economic development of the entire State. In addition, the Department is directed to amend and modify the plan in response to experience and changed conditions.

November 1984

Texas Department of Water Resources
Austin, Texas

GP-4-1

TEXAS DEPARTMENT OF WATER RESOURCES

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Lee B. M. Biggart, Commissioner
Ralph Roming, Commissioner

Published and distributed
by the
Texas Department of Water Resources
Post Office Box 13087
Austin, Texas 78711

PREFACE

Presented herein is an amended Texas Water Plan which sets forth planned actions and policies to address future water supply, water quality protection, water conservation, flood protection, and other water-related needs of the State. The history of water resources planning and development in Texas is discussed and the objectives of Texas water planning and the underlying concepts are described. Existing water resources and water uses, projections of future water requirements, and estimates of future water supplies are presented in regional and Statewide perspectives. Potential projects and associated costs to protect water quality, to solve water supply problems, and to meet as many of our future water needs as possible are identified. A companion document, *Volume 2—WATER FOR TEXAS: Technical Appendix*, contains more specific detail about the topics and planning concepts presented herein and also includes an analysis of current water development and use, future water needs, and potentially developable water supplies to meet projected water needs in each river and coastal basin of the State.

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VOLUME I

WATER FOR TEXAS: A Comprehensive Plan for the Future

INTRODUCTION AND BACKGROUND

How much water does Texas have? Is there enough for the people, the economy, and the environment? Will there be enough for future generations? Will it be safe to drink and to use in other ways? These fundamental questions exemplify the need to plan for water development, water conservation, and water quality management in Texas.

State policy explicitly provides for the conservation and development of natural resources. The Texas Department of Water Resources is the agency of the State given primary responsibility for implementing the provisions of the Constitution and laws of the State relating to the conservation and development of water.

State law directs the Executive Director of the Texas Department of Water Resources to prepare and maintain a comprehensive water plan for the orderly development and management of the State's water resources in order that sufficient water will be available at a reasonable cost to further the economic development of the entire State. In addition, the Department is directed to amend and modify the plan as experience and changed conditions require.

Water demands by people, industry, and agriculture, although somewhat seasonal, are continuous from hour to hour and day to day in many cases. In addition, water-using functions and enterprises cannot all be located adjacent to available water supplies. Thus, it is essential to plan, develop, operate, and maintain adequate water storage, water conveyance, water treatment, and wastewater treatment facilities for the existing people and the present economy, as well as to plan for the development of adequate facilities for the future as the population and the economy grow.

PLANNING AND DEVELOPMENT — 1900 TO 1983

Growing water demands and a highly variable climate have caused State government to develop legal and institutional arrangements to meet the water supply and water quality protection needs of the people and the economy. These arrangements include the roles of the private sector, local governments, regional authorities, State agencies, and federal agencies. Major legislative and institutional actions which underlie Texas water administration and planning (except court decisions) are listed below.[1]

In 1904, a constitutional amendment was adopted authorizing the first public development of water resources.

In 1913, the 33rd Legislature passed the first major irrigation act and created the State's first water agency — the Board of Water Engineers — to regulate appropriations of water. This act also created a water rights appropriation system based on a "first in time, first in right" priority.

In 1917, with the adoption of a constitutional amendment, Article 16, Section 59(a) of the Texas Constitution was passed. This article established the State's legal right to regulate and effectuate conservation of natural resources in the State.

In 1931, the 42nd Legislature, in the Wagstaff Act, established for the State the priorities of use that would be followed in the allocation of the State's water resources to various purposes. The preference list provided the following order for all streams in the State with the exception of the Rio Grande: (1) domestic and municipal uses, (2) processing (industrial), (3) irrigation, (4) mining and the recovery of minerals, (5) hydroelectric, (6) navigation, and (7) recreation and pleasure.

In 1944, the Texas Water Conservation Association was formed to provide a public forum for citizen participation in water matters. The Association has continued to the present.

In 1949, an appraisal of Texas water problems was prepared by the U.S. Bureau of Reclamation at the request of Senator Lyndon B. Johnson.

[1]Many water supply, water quality protection, drainage, and water conservation functions are carried out by local and regional units of government and the private sector. The legislation and administrative actions whereby these functions are specifically authorized and operated are voluminous and are not identified or discussed herein.

In 1949, the Texas Legislature enacted legislation which recognized underground water as private property of the landowners and authorized the creation of underground water conservation districts.

In 1952, Governor Allan Shivers appointed a 90-member committee, with J. B. Thomas of Fort Worth as chairman, to examine State water problems.

In 1953, the Thomas Committee recommended State financial assistance to local water projects, reorganization of the Board of Water Engineers, and preparation of a long-range water policy for the State.

In 1953, the Legislature created the Texas Water Pollution Advisory Council, composed of representatives of the Attorney General, State Health Department, Game and Fish Commission, Board of Water Engineers, and Railroad Commission, with the responsibility to focus the State program by coordinating State efforts.

During the period 1954-1956, Texas suffered the most severe drought in history. In approximately the western half of Texas, drought conditions also had prevailed during the preceeding four years and were continuous for seven years.

In 1956, the Federal Water Pollution Control Act (Public Law 84-660), enacted by the 84th Congress, authorized states to receive matching funds to finance pollution control programs and local municipalities to receive grants for up to 30 percent of the cost of the construction of waste treatment plants. The Act also strengthened provisions for federal enforcement of pollution laws.

In 1957, the drought was broken by terribly damaging floods.

In 1957, a legislative act created the Texas Water Development Board, and a constitutional amendment, approved by Texas voters, authorized the Board to administer a Water Development Fund of $200 million to help local communities develop water supplies.

In 1957, the Texas Water Planning Act of 1957, creating a Texas Water Resources Planning Division in the Board of Water Engineers, was enacted in a special session of the legislature.

In 1958, a report titled, "Water Developments and Potentialities of the State of Texas," was prepared as a joint effort by the U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, U.S. Soil Conservation Service, and Texas Board of Water Engineers. Senator Johnson caused the report to be published as Senate Document III, 85th Congress, Second Session.

In 1958, the Board of Water Engineers prepared and presented to the 56th Legislature a report titled "Texas Water Resources Planning at the End of the Year 1958." This report, prepared in response to a mandate in the Texas Water Planning Act of 1957, was essentially an inventory of the State's water resources and included recommendations for a State planning program.

In 1959, the U.S. Study Commission-Texas, created through a Congressional authorization requested by Senator Johnson, began a three-year study of land and water resources in the intrastate river basins of Texas.

In 1961, the 57th Legislature made important changes to State laws affecting water administration. The Board of Water Engineers was reorganized, renamed the Texas Water Commission, and given specific responsibilities for water planning. The Texas Water Pollution Control Board was created, replacing the Texas Water Pollution Advisory Council, and given specific duties and responsibilities including the approval of activities for pollution control work and issuance of waste disposal permits allowing the discharge of waste into State streams. Also, the Board was to promulgate and enforce rules and regulations to abate and prevent pollution, as well as coordinate among the various agencies having pollution control activities. The Board was part of the State Health Department.

In 1961, the Board of Water Engineers, at the request of Governor Price Daniel, prepared and released a report, "A Plan for Meeting the 1980 Water Requirements of Texas." This report, prepared with assistance from river authorities and water conservation districts, was essentially a plan of surface-water development for meeting municipal and industrial requirements to 1980.

In 1962, the U.S. Study Commission-Texas, a Commission of both federal and State representatives authorized by the 1957 Congressional Act, released its report recommending a plan of development for meeting the projected, 50-year water needs of the State. This plan covered only that part of the State lying within and between the Neches River Basin in the east and the Nueces River Basin in the west; that is, it included only rivers and their basins lying exclusively in Texas and excluded rivers flowing interstate, the Canadian, Cypress (Creek), Pecos, Red, Rio Grande, Sabine, and Sulphur.

In 1964, Governor John Connally, reacting to the fact that the U.S. Study Commission's report and other ongoing federal agency studies did not address the entire State, directed the Texas Water Commission to begin immediate development of a comprehensive State Water Plan. Emergency appropriations were made available to the Commission, and additional appropriations for the planning effort were also provided by the Legislature in 1965. In that year, the Legislature also restructured the State water agencies

by transferring the water resource planning functions to the Texas Water Development Board and renaming the Texas Water Commission as the Texas Water Rights Commission.

In 1965, Congress enacted the Water Resources Planning Act (Public Law 89-80) to encourage the conservation, development, and use of water and related land resources on a comprehensive and coordinated basis by federal, State and local governments, and private enterprise. The Act authorized states to receive matching grants for planning and created the Water Resources Council to review or revise these plans and formulate recommendations for the authorization of projects. At the same time, Congress amended the Federal Water Pollution Control Act to require that states adopt water quality standards for all "interstate waters," and failing that, the federal government had the option to do so.

Also in 1965, the U.S. Bureau of Reclamation released its Congressionally authorized planning report entitled the "Texas Basins Project," which recommended a coastal canal project to convey projected surplus water from southeastern Texas to various points of use along the coast, terminating in the Lower Rio Grande Valley.

In 1966, voters approved a constitutional amendment increasing the Water Development Fund to $400 million, expanding the scope of the fund's use, and placing limitations on interbasin transfers of water.

In 1966, the Texas Water Development Board's staff completed and released for public review the "Preliminary Texas Water Plan," which contained proposals for meeting the State's projected water needs through the year 2020, with the exception of the long-range needs of West Texas. In addition to proposing 53 new reservoirs, the preliminary plan envisioned a potential 980-mile long State Water Project, beginning in northeast Texas and culminating in the Lower Rio Grande Valley. During 1966, the Board held 27 public hearings and two public meetings on the preliminary plan. A hearing was held in each of the State's 23 river and coastal basins. Following these hearings, the Board substantially revised the preliminary plan.

In 1967, the Legislature passed the Texas Water Quality Act, creating the Texas Water Quality Board as a separate agency and abolishing the Water Pollution Control Board. Also in 1967, the Texas Water Quality Board adopted water quality standards for all waters in the State in accordance with the Federal Water Pollution Control Act of 1965, as amended, and the Texas Water Quality Act of 1967.

In 1967, the Texas Water Development Board initiated a cooperative program with the U.S. Geological Survey to collect data on the estuaries of Texas.

In late 1968, the Texas Water Development Board released the revised preliminary plan as the Texas Water Plan. In April 1969, the Texas Water Rights Commission conducted a public hearing in Austin on the water rights aspects of the Texas Water Plan. Shortly thereafter, the Commission issued an order finding that existing water rights had been adequately considered, and that the plan had taken into account modes and procedures for equitable adjustment of water rights affected by the plan. Subsequently, the Board formally adopted the 1968 Texas Water Plan as the flexible guide to State policy for the development of Texas water resources. The 1968 Texas Water Plan recommended development of 67 new major (greater than 5,000 acre-feet in capacity) reservoirs and two salt water barriers to meet the projected year 2020 water needs of the State and also provided a conceptual plan for storage, regulation, and distribution of some 12 to 13 million acre-feet of imported water, should it become available. The reservoirs recommended for development in the 1968 Texas Water Plan did not include off-channel reservoirs for condenser cooling in steam-electric power generation plants.

Since the adoption of the Texas Water Plan in 1969, construction of 43 major reservoirs and three reservoir enlargements has increased conservation storage capacity in the State by almost 10 million acre-feet. Of the 43 major reservoir projects completed since 1969, 24 were for water supply, 18 were off-channel cooling ponds for steam-electric power generation, and one project was for natural salt (chloride) control. Two major planning studies which considered the importation of surplus surface waters from outside the State were conducted. These studies indicate that importation is not economically feasible at this time. Presently, there are five major water supply reservoir projects under construction; however, actual construction work on two of these projects has been halted by court order.

The Texas Water Quality Act, amended by the 61st Legislature in 1969, was the basic State statute on water quality and water pollution control. It expressed State policy toward water quality control, created the Texas Water Quality Board, outlined a system of water quality control, coordinated water quality programs among the various State agencies and local governments, and provided a basis for coordinating State water quality programs with the federal government. The Act also included provisions concerning the pollution control authority of other agencies. Membership of the Board included representatives from the Railroad Commission, Texas Parks and Wildlife Department, Texas Water Development Board, and State Department of Health, in addition to three public members appointed by the Governor.

In 1969, the 61st Legislature enacted the Solid Waste Disposal Act to empower the State "to safeguard the health, welfare and physical property of the people through controlling the collection, handling, storage, and disposal of solid wastes." This Act assigned the Texas Water Quality Board jurisdiction for industrial solid waste management, and the State Health Department jurisdiction for management of municipal solid waste, as well as any mix of industrial solid waste routinely collected with municipal wastes. The Act provided that the Water Quality Board be consulted with respect to water pollution control and water quality, and the Department of Health, with respect to public health.

Between 1968 and 1970, the Texas Water Quality Board prepared an Oil Spill Contingency Plan for the State of Texas, which was approved by the Governor in 1970. The plan provided procedures to be followed in notifying the Board, the Governor's Office, other State agencies, and navigation districts in the event of an oil spill within the State. The plan also specified methods for containment and cleanup, communications, prevention of oil spills, and legal action.

In 1971, the 62nd Legislature passed, and the voters of the State approved, a constitutional amendment authorizing the Texas Water Development Board, at the direction of the Texas Water Quality Board, to issue $100 million in bonds for water quality enhancement.

In 1972, Congress amended the Water Pollution Control Act of 1956 with Public Law 92-500. These Federal Water Pollution Control Act Amendments had a significant impact on water quality planning. The Act established programs and interim goals to meet its objective using areawide waste treatment and management plans as its foundation. A broad, basin plan was prescribed in a format that could be easily and continuously updated. The law required the State management programs to specify a continuing planning process to maintain these plans, to be complemented by a facility plan which would develop the requirements for a single treatment plant or service area and lead to the selection, location, and construction of a specific facility to solve the local water quality problem. Less than one year after passage of Public Law 92-500, the State of Texas had produced (under Section 303(e) of that Act) four of the six basin water quality management plans approved nationwide. Plans for the remaining eleven major river basins in the State were completed and approved between 1973 and 1975.

Section 208 of the Act established areawide or regional planning for urban-industrial areas, where such an approach could be more cost-effective and comprehensive. The regulations required the Governor to designate the areas for 208 planning as well as the planning agency, to certify the acceptability of the plan, and to designate the management agency to implement the plan. A formal mechanism for handling the 208 planning process was established in Texas in 1974, when the Governor issued Executive Orders DB-18 and DB-18A in accordance with the Federal Water Pollution Control Act Amendments of 1972.

In 1973, the Board adopted a Continuing Planning Process containing a State strategy designed to meet the objectives of Section 303(e) of the Federal Water Pollution Control Act Amendments of 1972. It contained a Statewide assessment of water quality problems, criteria for developing the construction grant funding list, a schedule of basin planning, and other programs. In addition, the Board published a plan for industrial solid waste management in Texas, based on a survey of existing management practices. This survey was designed to provide new information to facilitate development of new regulations under the Solid Waste Disposal Act. In 1973, the Oil Spill Contingency Plan was also expanded to include spills and accidental discharges of both oil and hazardous substances, in accordance with provisions of the Federal Water Pollution Control Act Amendments of 1972 and revisions to the National Oil and Hazardous Substances Pollution Contingency Plan.

In 1973, the Mississippi River Commission, Corps of Engineers, and Bureau of Reclamation released the results of their studies of the Texas Water Plan, as authorized by a 1966 Congressional Act. The most significant of these reports was their study on the "West Texas-Eastern New Mexico Import Project," as conceptually proposed in the 1968 Texas Water Plan. The federal studies determined that the project was technically feasible, but under existing federal planning criteria it was not economically justified. The report recommended that no further studies be undertaken by Congress at that time.

Between 1972 and 1975, the Water Development Board's staff initiated a number of regional studies of water and related land resources in areas of Texas faced with severe water problems at that time. Studies were undertaken in cooperation with federal, State, and local agencies and the universities. These included a ground-water investigation for the El Paso area, and a comprehensive water supply and demand analysis for the San Antonio-Guadalupe River Basins.

In 1975, the 64th Texas Legislature enacted into law Senate Bill 137 which directed the Board to carry out comprehensive studies of the relationships between freshwater inflows and the biological productivity of Texas bays and estuaries. Reports of results of these studies were forwarded to the Legislature in 1979.

In 1975, the Governor designated eight areas in the State for 208 planning and financial assistance, with regional councils of governments as planning agencies and the Texas Water Quality Board having oversight responsibilities. Later that year, the 208 planning program was extended from urban-industrial areas to cover the entire State. Also in 1975, the Texas Water Quality Board expanded its regulatory program over industrial solid waste through a shipping control ticket or manifest system.

The enactment of the federal Resource Conservation and Recovery Act (RCRA) in 1976 expanded the State role in hazardous waste management. The law provided federal financial assistance to states to develop hazardous waste management programs equivalent to federal requirements and authorized approved states to implement these permitting and enforcement programs in lieu of federal programs. This involved the development of a State plan for solid waste management in Texas, evaluation of industrial solid waste management sites based on State and federal criteria, and development of public awareness and participation programs. In 1977, the Texas Solid Waste Disposal Act was amended to enable the State to assume administration of the RCRA program.

In 1976, Texas voters approved a constitutional amendment that increased the authorization for water quality enhancement funds from $100 million to $200 million. A corresponding amendment to increase the water development fund authorization by $400 million failed to pass.

In 1977, the Texas Water Development Board released a two-volume draft document titled, "Continuing Water Resources Planning and Development for Texas," which incorporated the results of the regional studies initiated in 1972 into a Statewide planning document for use in updating and revising the Texas Water Plan.

In 1977, the three water agencies existing at that time—Water Development Board, Water Rights Commission, and Water Quality Board—were combined by the Legislature, creating the Texas Department of Water Resources. The legislation provided that the former six-member Water Development Board continue as the Board for the new agency. The Water Quality Board was abolished and the Water Rights Commission was replaced by the Texas Water Commission, structured to carry out the judicial functions for the agency. Within this new single agency a multitude of responsibilities, including water resources planning, water quality protection, water rights administration, and water development loan administration, were placed.

Solid waste planning efforts were begun in 1978 with the Governor designating the Texas Department of Water Resources as the responsible agency for industrial solid waste planning activities under RCRA, and the Texas Department of Health as the responsible agency for municipal solid waste. This planning program consisted of data collection, grants administration, policy coordination, and public participation activities to assist in the development of the State Solid Waste Management Plan. The purpose of the industrial solid waste plan is to describe and evaluate the current program and suggest needed modifications. The plan serves as a policy guide for the recovery and reuse of industrial solid wastes, incorporates federal requirements for a State solid waste plan, and provides for the management of hazardous and non-hazardous industrial waste, which includes manufacturing, agricultural, and mining wastes, as well as air and water pollution control residuals.

During 1978 and 1979, most of the initial planning procedures under the 208 program were completed for eight urban-industrial areas as well as the remainder of the State. In 1979, the Governor certified and forwarded to the U.S. Environmental Protection Agency all 208 plans that had been completed. Altogether these comprised the State Water Quality Management Plan, which included local plans developed for wastewater treatment needs as well as specified water quality stream standards, water quality problem areas, waste load evaluations, and needed wastewater treatment and collection systems. The local plans, developed through contractual agreements with local planning agencies such as river authorities and councils of governments and reviewed by local advisory committees, had been approved by the Texas Water Development Board.

In 1979, the Governor issued an executive order designating the Texas Department of Water Resources as the State agency responsible for: coordinating all water quality management planning in the State; making recommendations to the Governor regarding designations; receiving grants for water quality management planning in the State planning area and conducting the planning (except for planning for agricultural/silvicultural nonpoint source pollution controls for which the Texas State Soil and Water Conservation Board was designated); and reviewing designated area plans. Continuing water quality management planning since that time has resulted in the development and approval of four major updating documents (Statewide wastewater facility needs) on an annual basis. Additionally, special studies have been conducted in many areas of the State to develop additional data concerning existing or potential problems identified in the initial 208 planning studies; the majority of these efforts have been through contractual agreements with local planning agencies. The staff of the Texas Department of Water Resources has also undertaken major efforts in the performance of intensive monitoring surveys and water quality

modeling which result in wasteload evaluations which prescribe levels of wastewater effluent quality necessary to maintain stream standards. These ongoing efforts also include the preparation of a biennial water quality inventory for the State and periodic (not less frequently than every three years) review and revision of the State's surface water quality standards.

For the period of 1975 through 1981, federal funding for water quality management planning in the designated areas had been provided through direct grants from the U.S. Environmental Protection Agency to the designated planning agencies (councils of governments). With the passage of the 1981 amendments to the federal Clean Water Act, the water quality management program moved into another phase with the entire program coordinated and funded through federal grants to the Texas Department of Water Resources. Federal funds are distributed, when appropriate, to local planning agencies for necessary studies on a priority basis.

In 1981, the draft State Solid Waste Management Plan was approved by the Texas Water Development Board and later approved by the U.S. Environmental Protection Agency.

In 1981, the Texas Legislature created the Texas Water Assistance Fund, to be administered by the Texas Water Development Board, and appropriated $40 million to this fund. A constitutional amendment (Proposition 4), which would have provided for one-half of the State's excess tax revenues each biennium to be deposited in the Water Assistance Fund, raised the 6 percent ceiling on authorized but unissued State of Texas bonds to 12 percent, and established a water bond guarantee program with $500 million of the general credit of the State was defeated.

In 1983, the Legislature designated the Texas Department of Water Resources as the State's lead agency in oil and hazardous substances spill response and expanded its jurisdiction from coastal areas to the entire State.

In accordance with directives of the Water Resources Development Act of 1976 (P.L. 94-587, Sec. 193), the Secretary of Commerce (acting through the Economic Development Administration), in cooperation with the Secretary of the Army (acting through the U.S. Army Corps of Engineers), and in cooperation with the States of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, Texas, and the private sector, conducted a study of the depletion of the natural resources of the High Plains region that depends upon the Ogallala Aquifer. The objective of the six-state High Plains Ogallala study was the determination of feasible resource development alternatives and recommendations (policies and actions) for assuring an adequate supply of food and fiber for the nation and a continuation of the economic vitality of the High Plains region. A report, with recommendations, was transmitted to Congress in January of 1983 by the six-state High Plains Study Council.

During consideration of Proposition 4 in 1981, criticism was voiced that there was no clear-cut plan which outlined specific water-related projects so that the Legislature and citizens would know which projects would be built with the proposed funds. Following the defeat of the proposition in the general election, the Texas Water Development Board was encouraged to proceed to prepare an amended water plan to be considered by the Legislature — a plan that would be acceptable and would contain the needed information and provisions to assure that needed water supplies are available for Texas to meet projected future requirements and also to contain an adequate financing mechanism to assure implementation of the plan.

A broad-based public involvement program was conducted early in 1982 to obtain citizens' views and ideas regarding Texas water problems and solutions. A comprehensive document was prepared which identified and described basic water policy issues in the State and was widely distributed for public review and comment. Public input was obtained through: (1) 13 public meetings; (2) written comments; (3) personal interviews with community and professional leaders knowledgeable in water matters; and (4) a professionally conducted public opinion poll.

Results were considered by a broad-based Task Force on Water Resource Use and Conservation, appointed by Governor Clements. Approximately 100 water leaders and leading citizens from all parts of Texas worked on this project, including presidents of the regional chambers of commerce — East, West, South, and Rio Grande Valley. The Task Force organized three working committees as follows: (1) Finance; (2) Water Resources Use and Conservation; and (3) Water Importation.

The Task Force Committees developed recommendations to the Governor and the Texas Energy and Natural Resources Advisory Council on the basis of results obtained from the public input program regarding water quality protection, water conservation, public education, environmental protection, water supply development, flood protection, water importation studies, water management, and State participation in water financing. A special committee of the Texas Municipal League also recommended that flood control and sewage treatment needs be included within a revised water plan and that a program of State financial assistance to individual communities, additional research and planning, and public education be emphasized in Texas water planning.

To the extent possible, the work to amend the Texas Water Plan has been based upon the public input and the committee recommendations. Using the latest information available, Department staff have revised and updated projections of population and economic growth for the period 1980 through 2030 for each county (and in the case of population, for most cities) of Texas, with specific projections for intervening points in time. From these projections of population and economic growth, estimates have been derived of the sewage treatment needs and the quantities of water that will be needed for people, industry, agriculture, fisheries, and other purposes in the future. Sewerage systems, water-supply facilities, and major water projects to meet municipal and industrial needs of most areas of the State have been identified both in terms of approximate location and time of construction. The projections and the projects were included in a draft planning report entitled "WATER FOR TEXAS: Planning for the Future" which was released by the Department in February 1983 for the purpose of receiving public input and amending the Texas Water Plan adopted by the Texas Water Development Board in 1969.

Subsequently, eight regional public hearings were held within the State to receive public response to the draft planning report. Public comments and recommendations received at these hearings have been considered in revising the draft planning report. A two-volume document which presents a plan for water conservation, water quality protection, water supply development, and water-related needs of Texas has been prepared. In *Volume 1 — WATER FOR TEXAS: A Comprehensive Plan for the Future*, data, information, planned actions, and policy recommendations are oriented toward regional and Statewide planning perspectives. In Volume 1, references are made to conditions or particular problems specific to a region or local area of the State. These references are used to highlight or exhibit a particular problem or solution and are not meant to be inclusive. The companion document to this Plan, *Volume 2 — WATER FOR TEXAS: Technical Appendix*, is organized and developed to provide more specific detail. Volume 2 contains background information and descriptive discussions of the topics and planning concepts included in Volume 1, along with identification of problems, projections of future water requirements, and estimates of water supplies potentially developable to meet projected demands within each zone of each river basin of the State.

OVERVIEW OF WATER PROBLEMS AND WATER RESOURCES

Water Problems

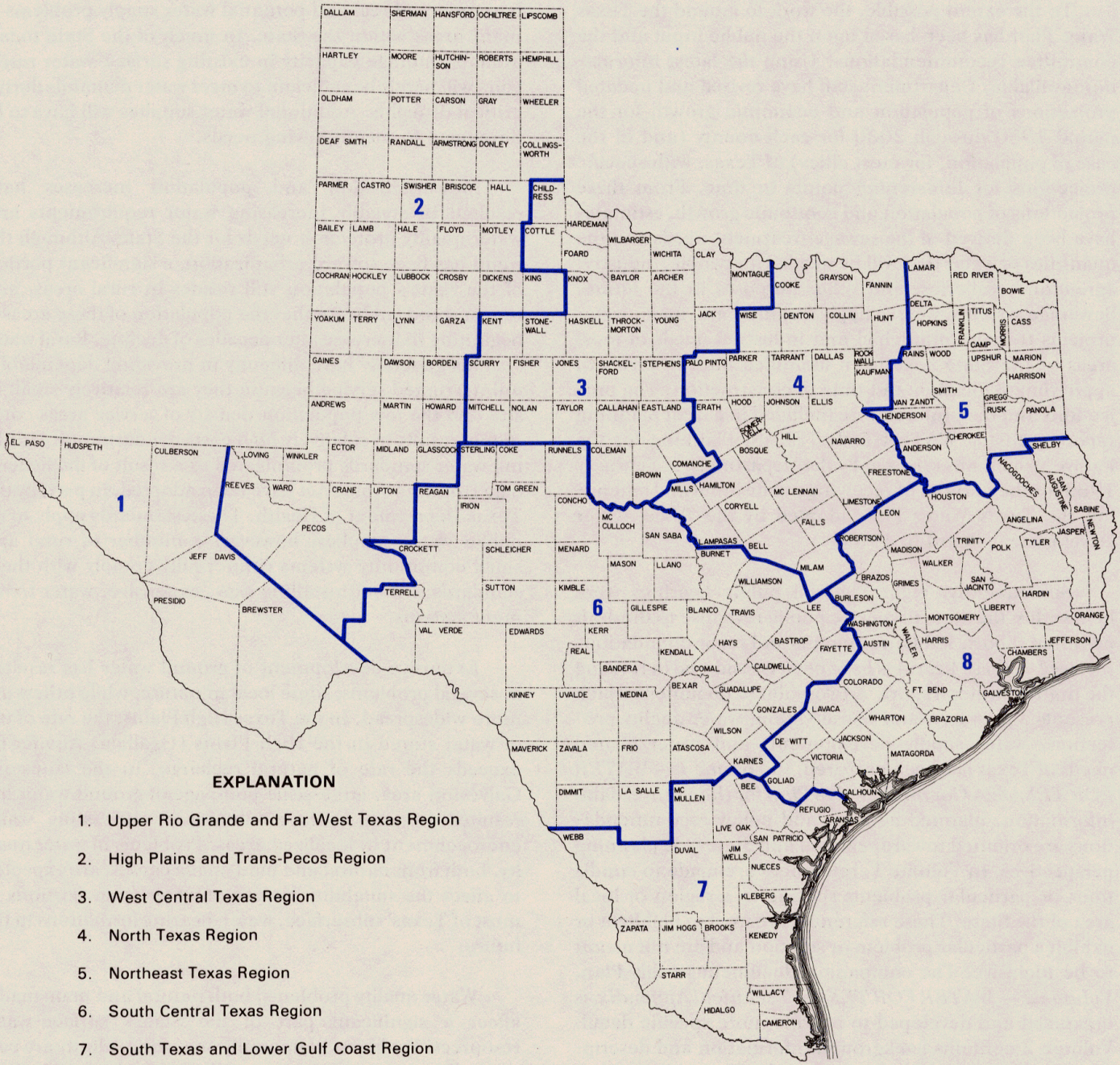
Rapid population growth and economic development, coupled with a climate in which water resources are scarce, have imposed real and potential water supply problems in many areas within the State. In much of the State today, available storage capacity in existing surface-water reservoirs will barely be sufficient to meet water demands during critical droughts. Additional water supplies will have to be developed to meet growing needs.

Industrialization and population increases have resulted in steadily increasing water requirements and water quality protection needs for the State. Although the trend has been toward urbanization, a significant portion of the State's population still resides in rural areas, and recent trends indicate that the population of these areas is beginning to increase after decades of decline. Rural water systems generally have difficulty in providing dependable, uninterrupted service because they are relatively small in size and the low population density of service areas commonly results in relatively high costs per customer. Drinking water standards promulgated as a result of the Federal Safe Drinking Water Act have been adopted, in part, by the Texas Department of Health. These standards apply to all public water supplies; however, a number of rural and small community systems cannot fully comply with these standards without installing new, expensive, water treatment systems.

Extensive development of ground water has resulted in several problems, some local in nature, while others are more widespread. In the Texas High Plains, the rate of use of water stored in the High Plains (Ogallala) Aquifer far exceeds the rate of natural recharge. In the Houston-Galveston area, large-scale pumpage of ground water has resulted in land surface subsidence and saline water encroachment in localized areas. Problems of water quality, both from natural and man-made causes, are expected to affect the suitability for use of water from portions of most of Texas' subsurface, water-bearing formations in the future.

Water quality problems, both natural and man-made, affect a significant part of the State's surface-water resources. Problems of naturally occurring salinity are particularly severe in the upper reaches of the Red, Colorado, Brazos, and Pecos River Basins and continue to plague development and full beneficial use of water resources in these basins. In these areas, natural pollution, primarily sodium chloride, results from salt springs and salt flats within the drainage areas of the basins. In some areas, this problem has been aggravated to some extent by oil and gas exploration and production activities.

Many of the man-made water quality problems occurring in Texas streams originate from highly populated urban areas which include Dallas-Fort Worth, Houston-Galveston, and San Antonio. The Trinity River below Dallas is dominated by treated sewage effluent during summer



EXPLANATION

1. Upper Rio Grande and Far West Texas Region
2. High Plains and Trans-Pecos Region
3. West Central Texas Region
4. North Texas Region
5. Northeast Texas Region
6. South Central Texas Region
7. South Texas and Lower Gulf Coast Region
8. Southeast Texas and Upper Gulf Coast Region

Figure 1. Major Geographical Regions in Texas

months. A similar situation exists in the San Antonio River below the San Antonio metropolitan area. In the Houston-Galveston metropolitan area, water quality problems are increasing with increasing urban and industrial development.

Serious flooding conditions have at one time or another struck most parts of the State. Flash flooding resulting from high-intensity rainstorms is common and not easily predicted. Also, the flat coastal area is vulnerable both to high tides and to heavy runoff from rainfall associated with tropical storms. In the coastal area, and in other parts of the State, the flat land surface is not particularly amenable to flood control by structural measures.

The potential effects of upstream water development on freshwater inflows to the bays and estuaries are of major concern to the State. Use of the bays for navigation, commercial shell dredging, commercial and sport fishing, oil and gas production, maintenance and propagation of marine life, and diverse recreational use is extensive. These activities make a major contribution to the viability of the State's economy. Estimates of the freshwater inflows needed for estuarine purposes, along with estimates of fresh water needed for other purposes, are included in the amended Plan.

The location of existing water supplies in relation to the areas of water need presents a significant water resource planning problem. In many areas, El Paso, the Texas High Plains, and the Lower Rio Grande Valley, for example, where existing ground-water supplies are beginning to be depleted, or where demands are beginning to exceed current surface-water supplies, there are no supplemental supplies available, except at great distances. This problem is compounded by limited availability and poor characteristics of dam and reservoir sites. Thus, supplemental water supplies, either surface or ground, may have to be transported great distances to meet future demands.

The major types of water and water-related problems in each of eight major geographic regions of the State (Figure 1) are described below.

Upper Rio Grande and the Far West Texas Region:

1. Water supplies are very limited. The surface-water and ground-water supplies of the Region are shared by Texas, New Mexico, and Mexico. During the past 30 years, the Rio Grande delivered only 65 percent of the water needed for the El Paso irrigation area.

2. High salinity in surface-water supplies due to frequent low flows, and increased salinity of municipal and agricultural return flows is detrimental to crops and cropland.

3. Ground water from the Hueco Bolson deposits is the primary source of municipal and industrial supply. The Bolson is being "mined" and saline water from adjacent saline water-bearing sands is encroaching upon the Bolson.

4. Fresh ground water is projected to meet El Paso's needs through 2010, but at higher costs for pumping and a poorer quality water.

5. Water supply for smaller cities is a problem now.

6. Flash flooding is a major problem.

Major Cities

El Paso

High Plains and Trans-Pecos Region:

1. Surface-water supplies are very scarce, with practically all such supplies already developed and dedicated.

2. The High Plains (Ogallala) Aquifer—the major source of municipal and irrigation water is being overdrafted. At the present time, the Ogallala supplies irrigation water to 4.6 million acres in the Southern High Plains (south of Canadian River) and 1.3 million acres in the Northern High Plains. By the year 2000, it is projected that the Ogallala can supply irrigation water to 7.5 million acres if an effective water conservation program is implemented and 6.0 million acres if effective conservation is not practiced throughout the area. By the year 2030, it is projected that the Ogallala can supply water to irrigate only 1.8 million acres (39 percent of the present acres) and 0.9 million acres (72 percent of present acres) in the Southern and Northern High Plains, respectively, if an effective water conservation program is not implemented.

3. Municipal and industrial water supplies are becoming more difficult to obtain and more expensive as the water table declines. Some major cities of the area will need additional supplies by 1990. Ground water in many areas is higher in fluoride and nitrate concentrations than the U.S. Environmental Protection Agency and the State allow for public consumption under the Federal Safe Drinking Water Act.

4. Localized flooding is a problem throughout the Region.

Major Cities

Odessa
Midland
Lubbock
Amarillo

West Central Texas Region:

1. Surface-water and ground-water supplies are very scarce.

2. Natural salt pollution in the upper reaches of the Red and Brazos River Basins precludes full utilization of the water resources of these basins. Also, leaking oil, gas, and salt water disposal wells and improper disposal of salt water incidental to oil and gas exploration and production have resulted in local contamination of fresh ground- and surface-water supplies.

3. High nitrate concentrations occur in the ground water in some areas due to natural phenomena, locally intensified by septic tanks, cesspools, feedlots, agricultural fertilizers, and cultivation practices. Locally, ground water is higher in fluoride than existing State standards for public consumption under the Federal Safe Drinking Water Act.

4. Major cities will need additional supplies within the next 25 to 30 years. Some smaller cities have experienced water shortages during droughts since 1980, and as a rule have poor quality water (relatively high chloride, fluoride, dissolved solids, and nitrate concentrations).

5. Brush infestation of rangeland and growth of woody species that obtain water directly from the water table or from the soils just above it (phreatophytes) compete with more useful plants for fresh water.

6. Agricultural land practices in some dryland farming areas cause increased infiltration of water directly from rainfall and from surface runoff. This has contributed to soils becoming water logged, highly mineralized, and completely unproductive.

7. Localized flooding is a problem throughout the Region.

Major Cities

Abilene
Wichita Falls

North Texas Region:

1. Surface-water development is near the maximum potential for the Upper Trinity River Basin. Water is being imported from neighboring basins to the east. Potential future surface-water projects to serve the region are located in neighboring basins to the east and the north.

2. Major cities have adequate supplies to meet projected needs until about 2000 to 2010. Cities served by the North Texas Municipal Water District are near critical water supply conditions.

3. Ground-water levels (Trinity Group Aquifer) have been lowered severely; thus, pumping costs are burdensome and will increase.

4. Quality of ground water is deteriorating as water levels decline. Fluoride concentrations of ground water are high. Surface-water quality suffers from high urban use pressures (dissolved oxygen, suspended solids, phosphates, fecal coliform, algal blooms, and aquatic plants).

5. Smaller cities throughout the area do not have adequate supplies to meet growth needs. Many are barely meeting current needs.

6. Major flooding problems exist in the Region.

7. High chloride concentrations in Lake Texoma in the Red River Basin and reservoirs in the middle Brazos River Basin preclude full utilization of the water resources of these basins.

Major Cities

Dallas	Garland	Denton
Fort Worth	Killeen	Plano
Waco	Temple	Richardson
Arlington	Sherman	Irving
Denison		

Northeast Texas Region:

1. Surface-water and ground-water resources are potentially available to meet projected needs, if projects are planned and developed on schedule.

2. Rapid growth due to development and use of lignite reserves is expected.

3. Water and air quality protection and land reclamation from strip mining are potential problems for this area.

4. In many areas, shallow ground water has high concentrations of iron and is acidic, which makes the water undesirable for municipal use and many manu-

facturing processes. These problems generally can be solved by completing wells in deeper water-bearing sands or by expensive treatment of water from shallow wells.

5. Presently, water supplies for many smaller cities are inadequate in both quality and quantity.

6. Flooding problems are present in local areas.

7. Periodically, dissolved oxygen content in streams is low due to low stream flow and low natural reaeration rates.

Major Cities

Tyler
Longview
Texarkana
Marshall

South Central Texas Region:

1. Rapid growth of cities and suburban areas is straining existing water supply and waste disposal facilities and subjecting many citizens to threat of flooding.

2. Development of surface-water projects is needed to firm up municipal supplies and reduce reliance on the Edwards (Balcones Fault Zone) Aquifer in critical drought periods. Increased use of surface water would also assist in maintaining the ecosystems and recreational opportunities of Leona, San Pedro, San Antonio, Hueco, Comal, and San Marcos Springs, and the base flow of streams to the south of the aquifer.

3. Continued protection of the Edwards (Balcones Fault Zone) Aquifer from pollution is essential.

4. Pumping from the Carrizo Aquifer in the Winter Garden area has lowered water levels more than 400 feet since 1930. Poor quality water is encroaching into the aquifer in this area. Pumping costs may soon render this aquifer an uneconomic source of irrigation water.

5. The Guadalupe, San Antonio, and lower Colorado River Basins have potential surface-water projects that can be developed.

6. The upper Colorado River Basin has serious water quality problems due to inflow of saline ground water.

7. The Region has other local salinity problems and flooding problems from locally intense storms.

Major Cities

Austin
San Antonio
San Angelo

South Texas and Lower Gulf Coast Region:

1. The Region has insufficient quantities of surface water and ground water to meet growth needs for all water-using purposes. Surface-water supplies are practically all developed and committed. During extended drought periods, some of the current requirements cannot be met.

2. Soil salinity and drainage problems are present locally.

3. Flooding and storm surge problems exist.

4. Woody species that obtain water from the water table or from the soils just above it (phreatophytes) compete with more useful plants for water.

5. Surface-water quality in the region is generally good, but low dissolved oxygen occurs in some stream segments during summer months.

6. Navigation facilities, channel maintenance, dredge spoil disposal, and bay and estuary protection require continuing management programs.

Major Cities

Brownsville	Laredo	Harlingen
Kingsville	McAllen	Corpus Christi

Southeast Texas and Upper Gulf Coast Region:

1. Land surface subsidence and salt water encroachment result from overdevelopment of ground-water supplies.

2. The Houston and Galveston areas have water supplies to meet growing needs until 1990 to 1995.

3. Smaller cities are having problems from lack of surface-water availability and insufficient treatment, conveyance, and storage facilities.

4. Storm surge flooding and drainage problems are present.

5. Salt water intrusion during periods of low flow in the Brazos, Neches, and Trinity Rivers has the potential

for contaminating the freshwater supply at existing intake facilities.

6. Navigation facilities, channel maintenance, dredge spoil disposal, and bay and estuary protection require continuing management programs.

7. Water quality problems require a continuing management program.

Major Cities

Houston	Victoria	Nacogdoches
Galveston	Bryan	Huntsville
Beaumont	College Station	Orange
Port Arthur	Lufkin	

The conditions described above are illustrative of the types of water problems present in major geographic areas of Texas. However, it is emphasized that each area has significant water resources and water resource facilities that are now being used. These problems have been identified for the purpose of developing and suggesting plans to solve as many of them as possible.

Ground-Water Resources, Development, and Use

More than 50 percent of Texas is underlain by seven major aquifers and sixteen minor aquifers (Figures 2 and 3). Collectively, these aquifers receive an average annual natural recharge of about 5.3 million acre-feet (one acre-foot of water equals 325,851 gallons) and contain about 430 million acre-feet of water in storage that is recoverable using conventional water well technology. Of this total, about 89 percent, or 385 million acre-feet, is in the High Plains (Ogallala) Aquifer. Of the 17.9 million acre-feet of water that Texans currently use annually, about 10.9 million acre-feet is from ground-water sources. Of the 10.9 million acre-feet of ground water used, 11.9 percent, or 1.3 million acre-feet, is for municipal uses; 2.3 percent, or 249 thousand acre-feet, is for manufacturing purposes; 0.5 percent, or 53 thousand acre-feet, is for steam-electric power generation; 1.7 percent, or 183 thousand acre-feet, is for mining; 1.1 percent, or 120 thousand acre-feet, is for livestock watering; and 82.5 percent, or 8.9 million acre-feet, is for irrigation. About 50 percent of municipal water is obtained from ground-water sources. Ground water is used for municipal purposes in all areas of Texas and in practically every county. However, in many areas, the long-term use of ground water is lowering water levels to the extent that major water supply problems are occurring, or are projected to occur, in the foreseeable future.

Surface-Water Resources, Development, and Use

Texas has 15 major river basins and eight coastal basins which have approximately 3,700 designated streams and tributaries and more than 80,000 miles of streambed, 16,000 miles of which are subject to specific numerical water quality criteria established and adopted by the Department of Water Resources in cooperation with the U.S. Environmental Protection Agency (Figure 4). Long-term average annual precipitation ranges from 8 inches in the El Paso area to more than 56 inches in the Beaumont area (Figure 5). Average annual runoff (streamflow) is about 49 million acre-feet. Runoff ranges from about 1,100 acre-feet per square mile at the Texas-Louisiana border to practically zero in parts of the Trans-Pecos Region of far West Texas. From 1940 through 1970, Statewide runoff averaged 57 million acre-feet per year during the wettest period (1940-1950), and 23 million acre-feet per year during the severe drought of the early and mid-1950's.

There are currently 184 major reservoirs (36 federal and 148 non-federal) with 5,000 acre-feet or greater total capacity in Texas (Plate 1). In addition, there are five reservoirs presently under construction (four federal and one non-federal). Conservation storage capacity in existing major reservoirs and those under construction totals about 32.3 million acre-feet. Flood control storage capacity totals about 17.5 million acre-feet. The dependable (firm) water supply—the uniform yield that can be withdrawn annually from conservation storage through extended drought periods—from major reservoirs is about 11 million acre-feet annually. Texans now use about 7.0 million acre-feet (64 percent) of this dependable surface-water supply. A little over 21.7 percent is for municipal uses, 18.2 percent is for manufacturing purposes, 3.9 percent is for stream-electric power generation, 0.8 percent is for mining, 1.8 percent is for livestock watering, and 53.5 percent is for irrigation. A large portion of the remaining 4.0 million acre-feet of dependable surface-water supply is committed through permits and contracts to meet growing municipal and industrial needs of major metropolitan areas of the State over the next 30 years. This supply, however, will not meet all of the projected municipal and industrial needs of many Central, South, North Central, and West Texas cities. It is also projected that many cities in the eastern part of the State will need to develop additional surface-water supplies in the near future.

Water Quality

The quality of State waters has improved significantly during the last decade. Most of this improvement is directly related to the establishment of the Texas Water Quality Management Program and recent advances in wastewater treatment by industries and municipalities. The Department has determined that 244 of the 311 State Water Quality Segments currently comply with applicable stream